Seeking a Successful Paradigm for Realizing the Energy-Efficient Potential of the Indian Building Sector

Satish Kumar

Energy Efficiency Ambassador and Vice President
Schneider Electric India Pvt. Ltd.

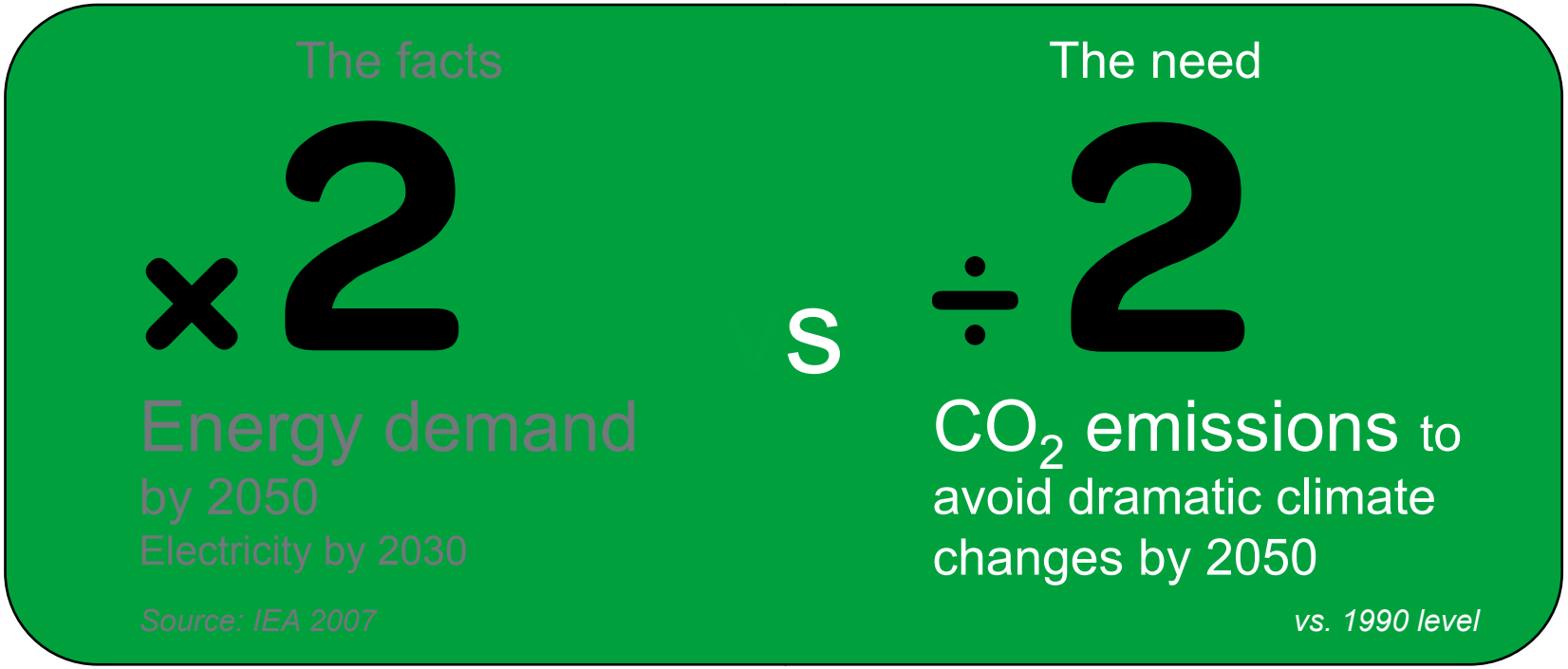
Lawrence Berkeley National Laboratory, Berkeley

November 11th, 2011

Schneider Electric

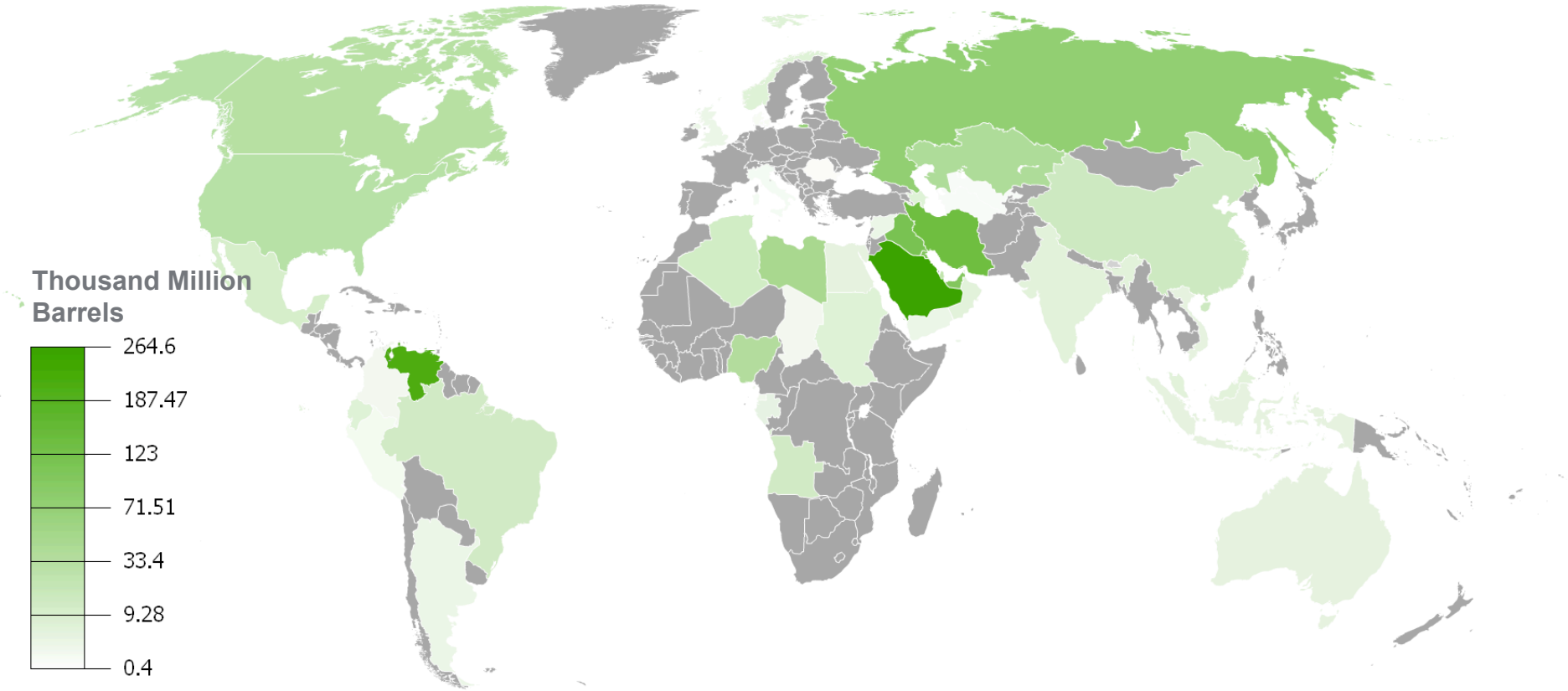
Background

The Energy Challenge/Dilemma



How to address this challenge?

Proven Reserves of Oil

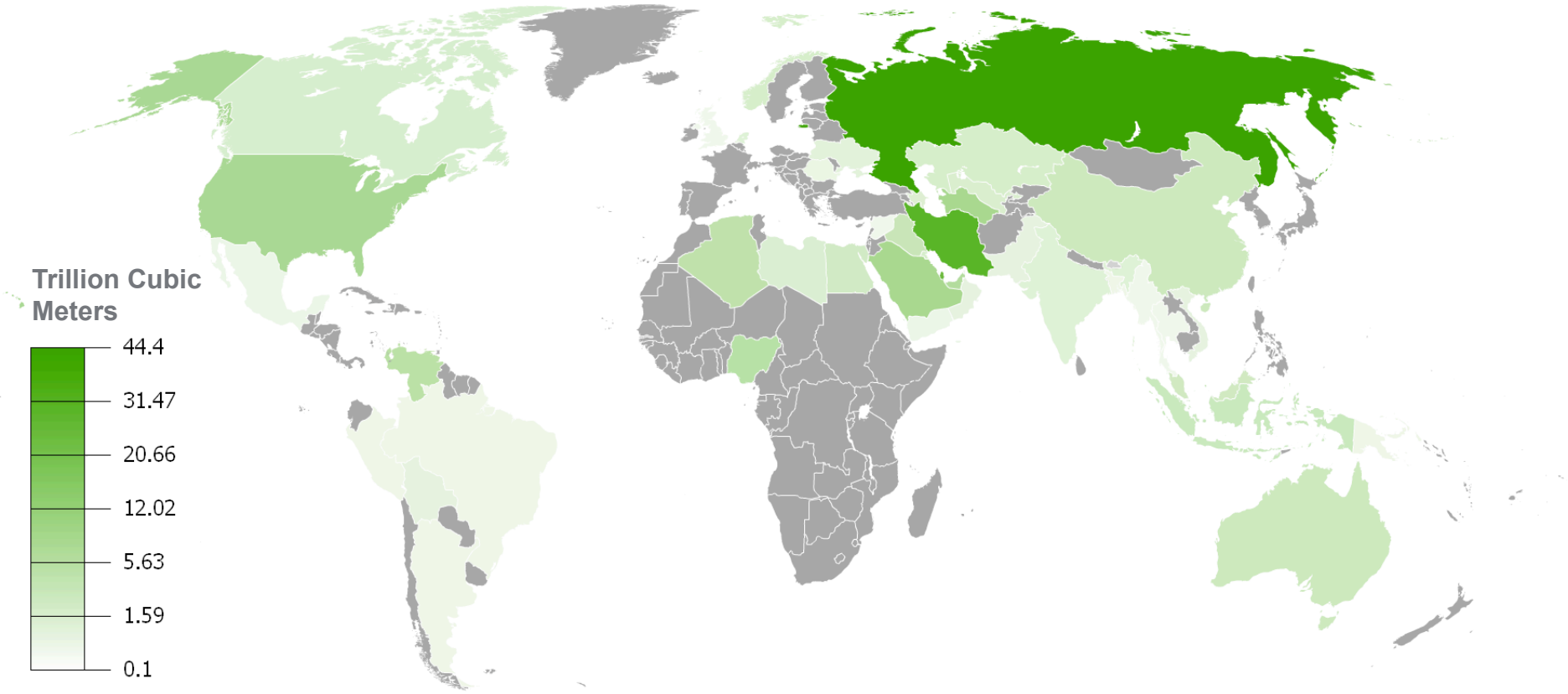


World Oil Reserves: 1,383 billion Barrels
World Oil Consumption: 32 billion Barrels per year
World Oil would last for 43 years

Source: BP's Statistical Review of World Energy

Courtesy: http://gunn.co.nz/map/

Proven Reserves of Natural Gas

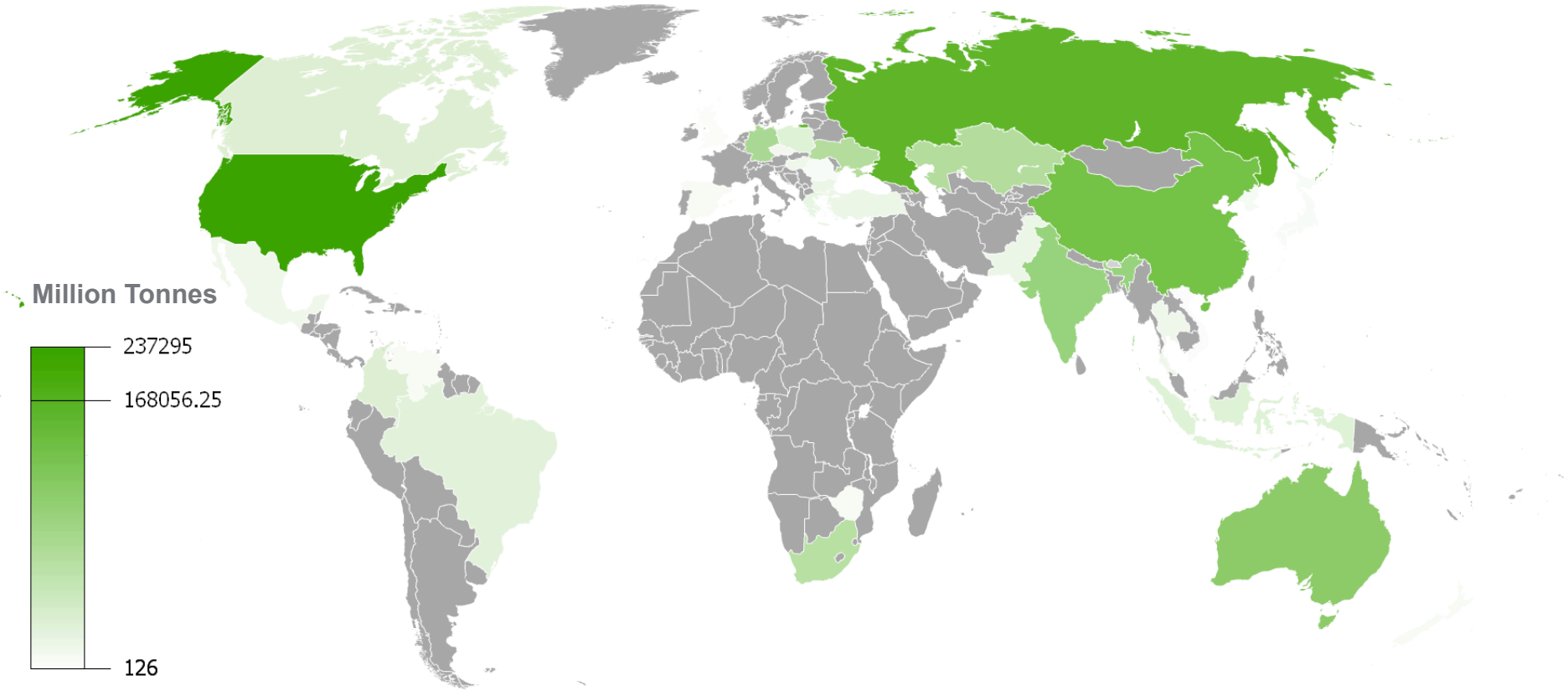


World Gas Reserves: 187 trillion cu m
World Gas Consumption: 3169 billion cu m per year
World Gas would last for 59 years

Source: BP's Statistical Review of World Energy

Courtesy: http://gunn.co.nz/map/

Proven Reserves of Coal

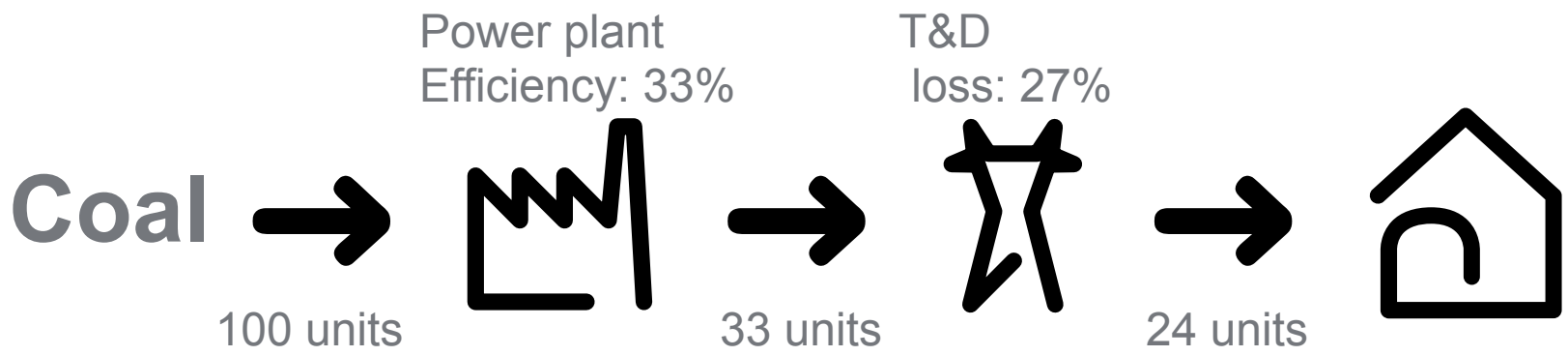


World Coal Reserves: 861 billion tones
World Coal Consumption: 5080 million tones per year
World Coal would last for 169 yrs

Source: BP's Statistical Review of World Energy

Courtesy: http://gunn.co.nz/map/

Energy Efficiency is a No Brainer



1 unit saved at end user = **4.2 units saved at the power plant**

T & D Losses also include electricity losses unaccounted for

Source: Central Electricity Authority (2009)

Number of People Without Access to Electricity and Relying on Biomass (million)

Countries/Region	# of People Lacking Access to Electricity	# of People Using Biomass for Cooking
Africa	587	657
Sub- Saharan Africa	585	653
Developing Asia	799	1,937
China	**8**	**423**
India	**404**	**855**
Other Asia	387	659
Latin America	31	85
Developing Countries*	1,438	2,679
World**	**1,441**	**2,679**

Note: *Includes Middle East Countries, ** Includes OECD and Transition Economies

Source: Energy Poverty, International Energy Agency (2010)

Top Building Energy Efficiency Policy Recommendations

- Building Sector
  - Building codes for new buildings;
  - Policy packages to promote energy efficiency in existing buildings;
  - Building certification schemes;
  - Collection of high quality energy efficiency data for industry;
  - Assistance in developing energy management capability;
  - Compliance, monitoring, enforcement and evaluation of energy efficiency measures

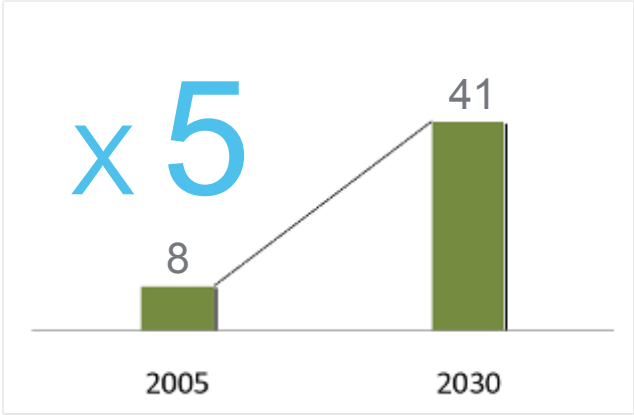
Source: International Energy Agency

Building Sector in India

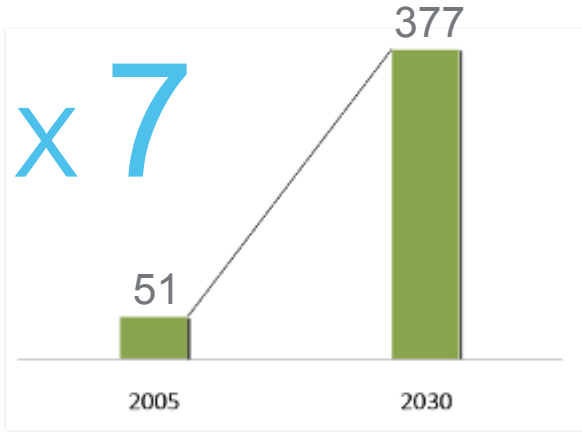
- a fast-growing sector
  - **60-70%** of buildings in 2030 yet to be built
- an energy-guzzling sector
  - Electricity growth at **13%** per year in the commercial sector over last five years
  - Large proliferation of DG-powered or DG-backup
- a partially regulated, multi-labelled sector
  - Many certification programs to choose from
  - but gap between registrations (**1280** buildings) and certifications (**200** buildings!)
- a diverse sector
  - public and private buildings
  - offices, hospitals, hotels and shopping malls – all have different needs
- … and a largely inefficient sector (new construction)
  - Except for pockets of excellence (e.g. green buildings)
  - **Typical new construction** have poor energy intensity **(kWh/m2/year)**

Sustainable Growth Conundrum - I

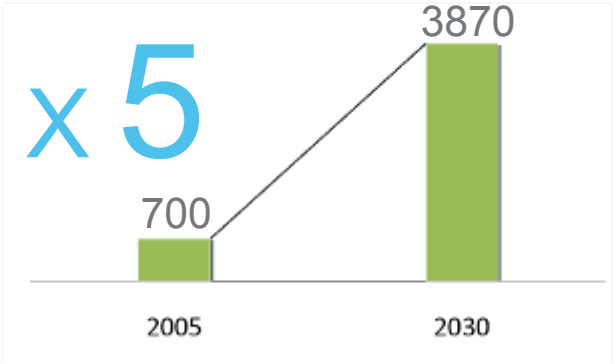
Total Floor Space (Billion m^2)
Includes Commercial and Residential



Vehicle Fleet (Millions)
Includes 2 and 3 wheelers,
Passenger Vehicles, Buses and Trucks

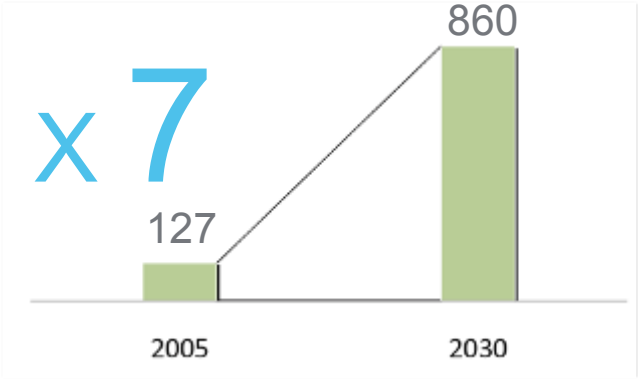


Total Power Demand (Terawatt hours)
Includes both Utilities and Captive

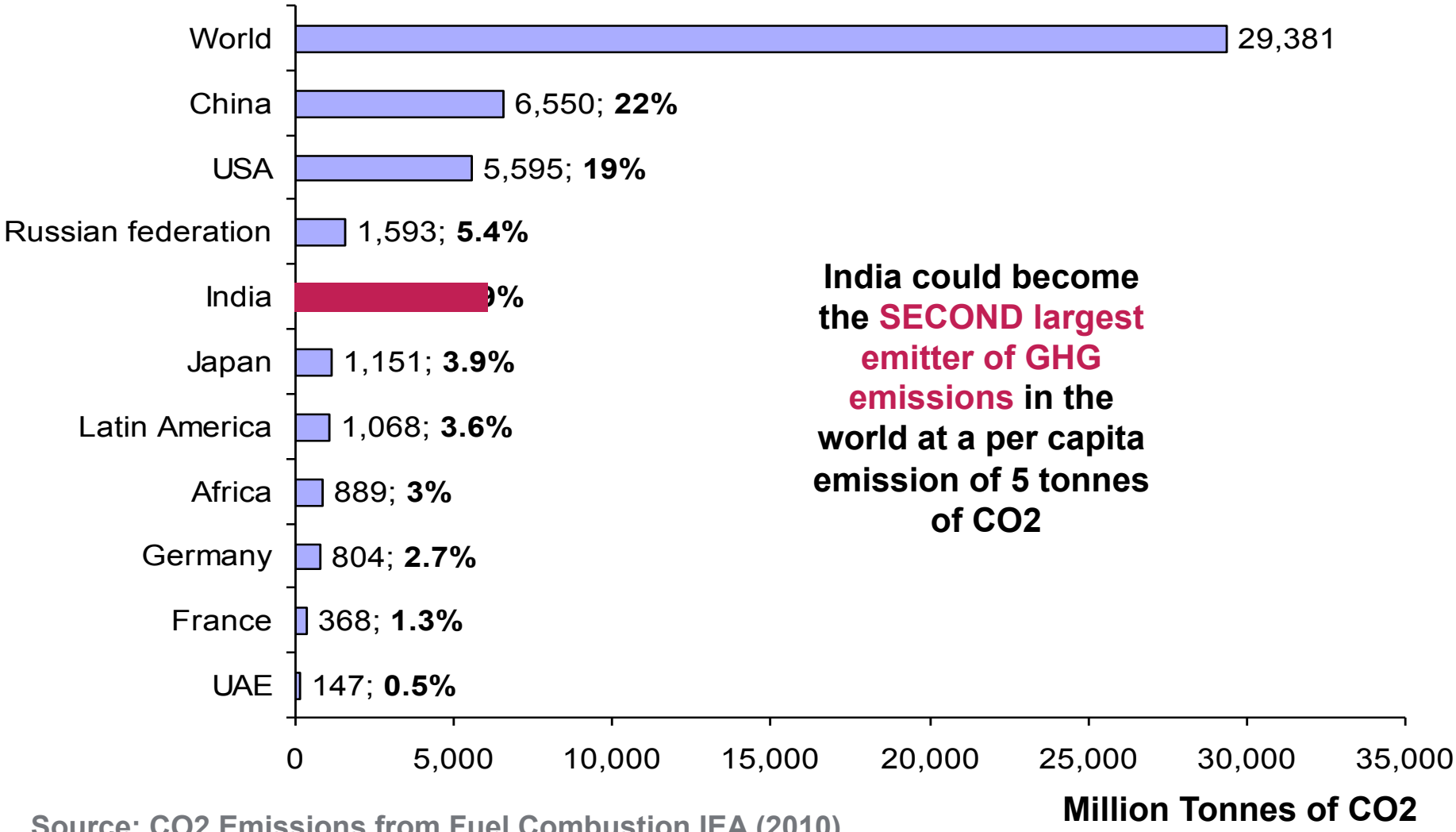


Source: McKinsey analysis

Cement Demand (Million tonnes)



Sustainable Growth Conundrum - II



India could become the SECOND largest emitter of GHG emissions in the world at a per capita emission of 5 tonnes of CO2

Source: CO2 Emissions from Fuel Combustion IEA (2010)

Focus on India: Regulatory and Policy Making Bodies in EE and RE

- Ministry of Power
  - Restructured accelerated power development and reforms program (R-APDRP)
  - Smart grid forum: consortium of government, industry, academia and research, to drive smart grid programs
- Bureau of Energy Efficiency
  - Minimum Perofrmance Code (ECBC) for Commercial Buildings with Connected Load of 100 kW or more
  - Perform, Achieve, Trade program to improve energy efficiency in the industrial sector
  - Minimum Energy Performance Standards and Labels for appliances, including inverters/UPS and distribution transformers
- Ministry of New and Renewable Energy
  - 20,000 MW of Solar Power by 2022, 20 M m^2 of solar collector, 20 M solar lighting
- Bureau of Indian Standards
  - ISO Copunterpart
  - Release of ISO/IS 50001
  - Development of Sustainability Section as a supplement of National Building Code
  - Technical Committee to coordinate national action vis-à-vis ISO 242 and ISO 257
  - Schneider Electric participating on all technical committees and administering the ISO 50001 training/awareness program
- Ministry of Urban Development
  - Implementation of ECBC at state and city/ town levels
- National Mission on Hybrid and Electric Vehicles
  - To promote cleaner technologies in automotive sector, bringing all stakeholders together
  - Fast track evaluation of EV potential in India underway

Building Energy Code

The Crisis of Importance in the Building Design/Construction Sector

- **Developers and Financiers**: Nothing happens without us
- **Architect/Engineers/Consultants**: We are the Ideas People; we make the dreams come true
- **Policymaker/Regulators**: Without the codes and standards and the approvals, no project can proceed
- **Technology Vendors**: Without technologies, we would still be living in huts with thatched roofs. Of course, we are the most important one
- **Building Trades and On-Site workers**: We just have to put everything together and it is the easiest part. We are not important.

The Fine Print Nobody Paid Attention to

- Powers and Functions of BEE vis-à-vis ECBC
  - Prescribe ECBC for efficient use of energy
  - Link **Energy Performance Index (from the EC Act) to the ECBC Prescriptive Compliance Approach** in order to facilitate the implementation of the Code

[On Page 5, clause (j) of the EC Act, 2001 currently reads:

"energy conservation building codes" means the norms and standards of energy consumption expressed in terms of per square meter of the area wherein energy is used and includes the location of the building]

- Power of State Government:
  - May amend ECBC to suit the regional and local climatic conditions with respect to use of energy in the buildings
  - May direct the owner or occupier of a building (if notified as a Designated Consumer) to comply with the provisions of ECBC

SOURCE: Energy Conservation Act (2001)

ECBC Challenge

- Outcome Based Code
  - Implied by the EC Act
- Compliance and Implementation Framework
  - Capacity of the existing system
  - Role of compliance tools (www.eetools.in)
    - Prescriptive and Whole Building Performance
    - Need to continuously update and refine tools
- Role and Responsibilities and Preparedness
  - Coordination between Ministry of Urban Development and Ministry of Power
  - Coordination between central and state govt.

Outcome-based ECBC

ADVANTAGES

- May be more cost-effective
  - Easy to integrate within the existing framework with few modifications
- Requires less rigorous resources and training for enforcement
  - Differentiate between experts and inspectors/officials with basic knowledge
- Compliance can be integrated with DSM programs more easily
  - Utilities can be involved in Code enforcement
- Holding the Designers Adhere/Comply with Performance Briefs
  - Incorporate Disruptive Technologies esp. in HVAC

BARRIERS and OPPORTUNITIES

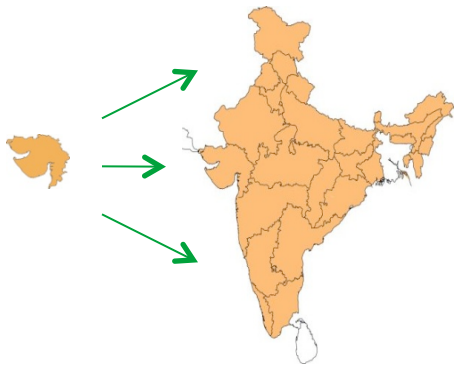
- Shifting/Sharing responsibility of implementation from Architect/ Engineer/ Consultant to User/ Facility manager
- **Baselining and Benchmarking (function and operation) becomes critical**
  - Data collection during compliance – continuous improvement of database
  - Online tool ECOBench – http://ecobench.eetools.in/
- Opportunity to develop Thermal Comfort Standards for India
  - Need to create standards for uniform indoor environmental quality
  - Opportunity to offset a significant portion of AC related power demand

ECBC Implementation Strategy

Moving from Technical Content Development & Capacity Building to Implementation

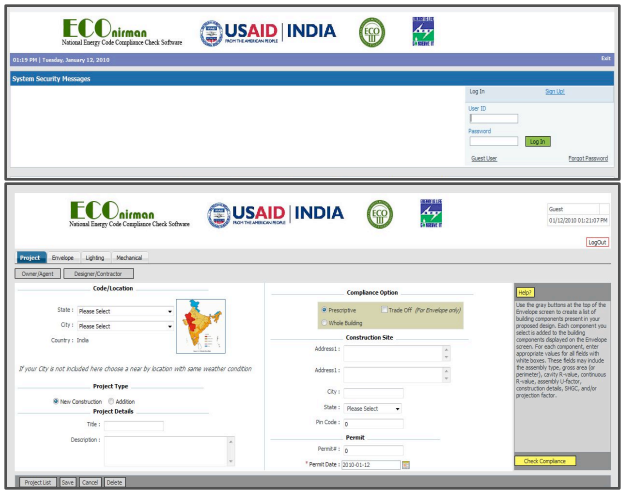
ECBC Implementation Roadmap

- Framework to test ECBC implementation in one state
- Scale up the model



ECBC Compliance Check Tools

- ECOnirman to check perspective and trade-off compliance



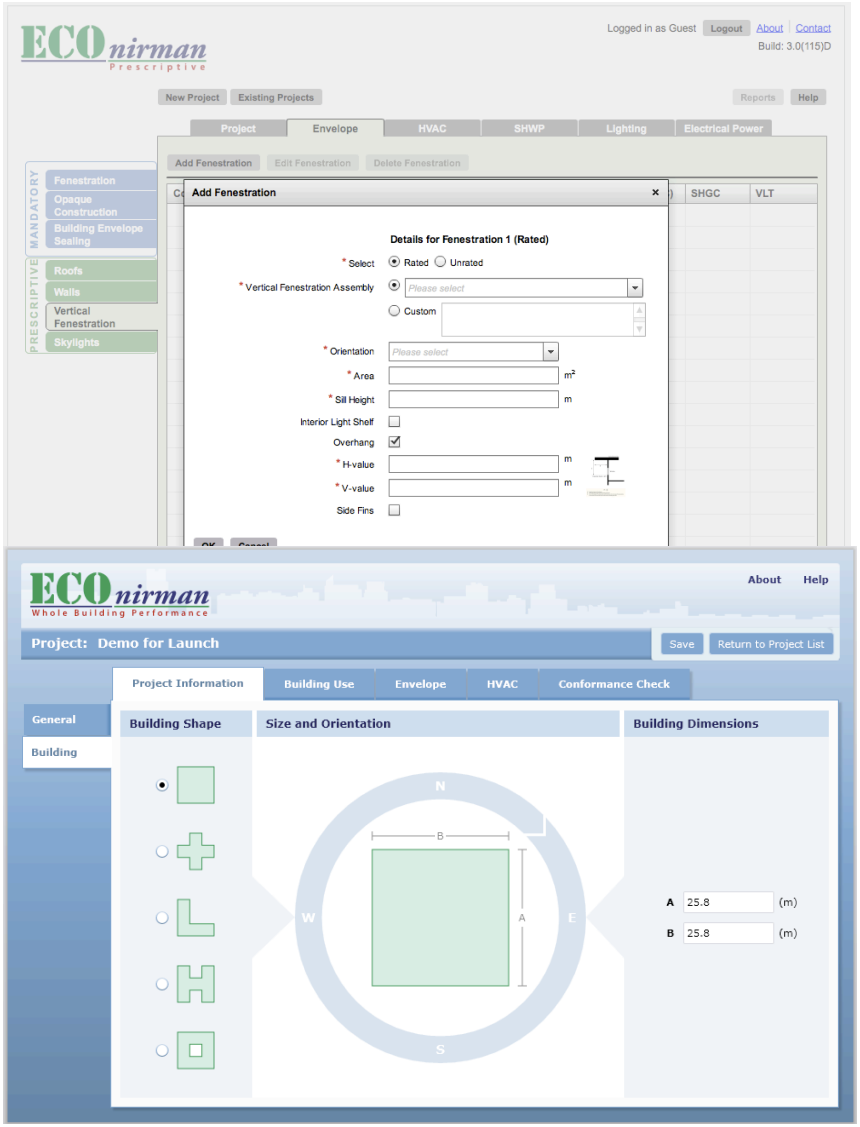
Certified Building Energy Professionals

- Introduce rigor through a BEE-Certified program
- Fully conversant with ECBC clauses and specifications
  - Basic understanding of building physics
- Training and certification for ECBC Evaluators/Code Compliance officials

Motivation for ECBC Compliance Tool

- Move ECBC from Voluntary to Mandatory Phase
- Transparent ECBC Compliance Option
  - Prescriptive and Trade-off
- Overcome the Capacity Challenge
- Wide Reach and Online Benefits
- Implementation and Learning Tool for Developers, Architects, Contractors, Owners, and Consultants
- Help Develop Building and System Database

ECBC Conformance Check Tool: ECOnirman



Status of Code Compliance Tools Development

- ECBC Compliance
  - 1st Phase: Prescriptive and Trade-Off (Completed)
  - 2nd Phase: Whole Building Performance (Completed)
- Full and Partial Compliance
- Stand Alone Tool
  - Web-based version ready
  - Desktop Version (Yet to be done)
- Covers Building Envelope, Lighting, HVAC, Service Water Heating and Pumping, and Electric Power requirements
- Modular and Scalable
  - Whole Building Performance Office Building Type can be extended to other building type

Technical Rigor or Degree of Compliance

- Ideally Both
- Beware of the rhetoric
  - "Imported" standard
  - Formulated to promote foreign products/technology
- Be prepared to counter it
  - Building Physics does not change
  - Encourage people to use traditional materials and contextual design practices (courtyard, overhangs)
- Every state wants its *own* standard
- Focus on capacity and institutional mechanisms first
- Adopt a phased approach to introducing technical rigor and tightening the standards

Where the Big Savings/Impacts Are?

- Residential Floor Space is 8-10x Commercial Floor Space (McKinsey)
- Residential sector consumes 3x electricity than commercial sector (CEA)
- If biomass is included, residential sector consumer 6-7x energy than commercial sector (IEA)
- Still, there are no energy codes or energy-efficient design guidelines for residential sector
- Leadership by CPWD, HUD, Residential Real Estate Developers: New Construction and Retrofits.

Existing Buildings

Benchmarking: Foundation for Developing Sound Performance Indicators

- Provide a Framework for Meeting ECBC Related Stipulations in the EC Act
  - Help in quantifying energy savings from ECBC
- Help Prepare Before Building Energy Audit
  - No need to start with “Investment Grade Audits”
  - Help in developing a graduated response to building performance issues
- Can be used to provide Performance briefs to Design Teams
  - System-Level Benchmarking Needed
- Can be used as the basis for Existing Building Rating Programs

Performance Based Rating and Benchmarking

- Objective
  - A rating scheme based on **actual performance** and **contextual data** rather than design intent
- Guiding Principles
  - Evaluate energy performance for **whole building**
  - Reflect actual **billed energy data**
  - Provide comparison mechanism among **peer groups**
  - Account for operational characteristics of the building and **not penalize for higher levels of service and amenities**
  - Provide a simple metric to evaluate and communicate building energy performance to owners, occupants, lenders, appraisers, and energy product and service community

Technical and Statistical Approach

- All buildings are different!
  - Different uses - office, hospitals, hotels, ...
  - Different sizes
  - Different number of hours in a day - 1/2/3 shifts, ...
  - Different number of users
    - # workers in office, # beds in hospital, # rooms in hotel, ...
  - Different geographic regions - climate, urban, …
  - **Use the Power of Statistics**
- Some buildings perform better than others
  - Impact of design
  - Impact of systems/equipment (Technology)
  - Impact of the Facilities team
  - **Use technical analysis to set more stringent codes and standards**

Source: Usable Building Trust, ps Analytics

Benchmarked Energy Use for Commercial Buildings in India

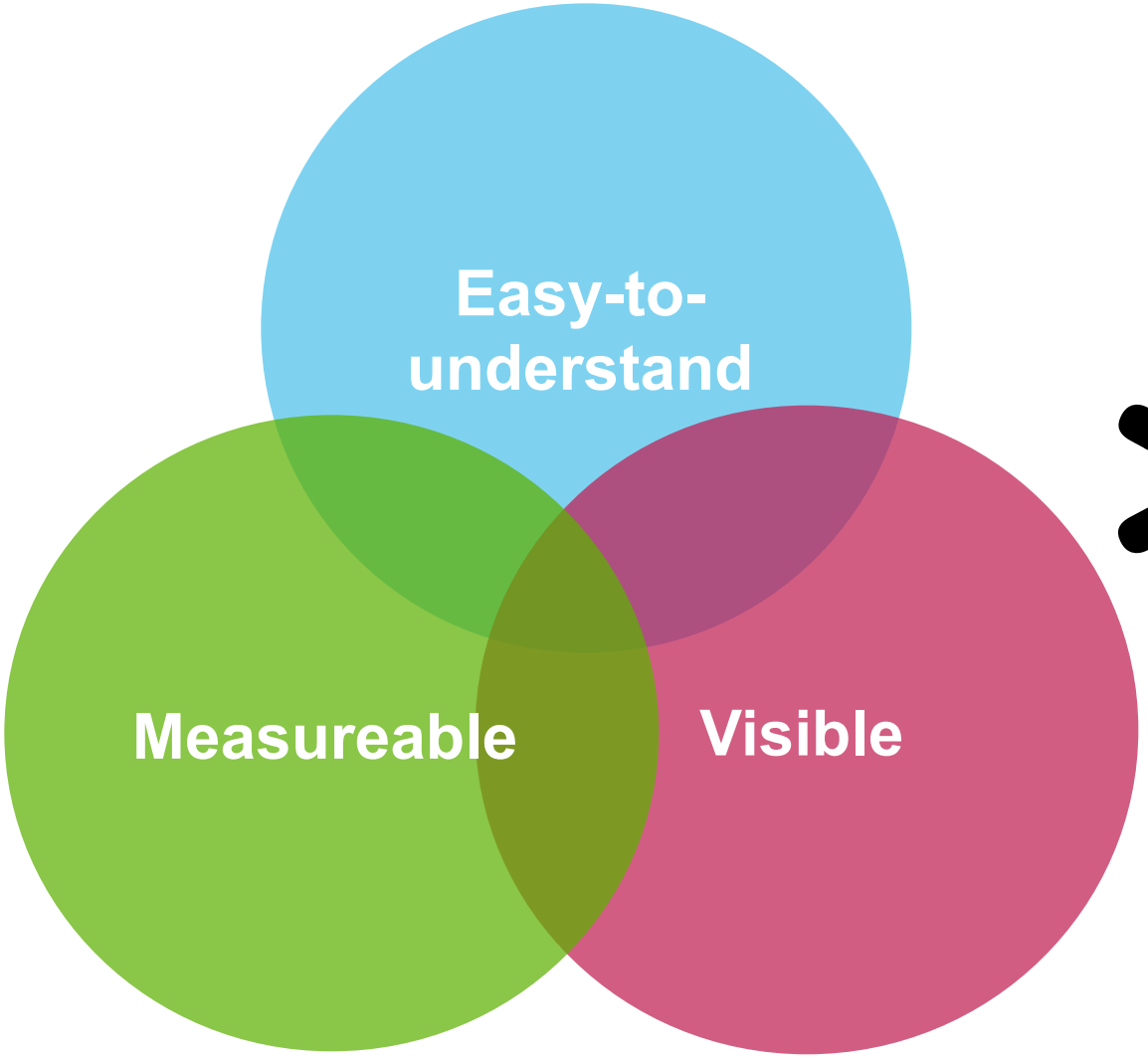
Offices	# Annual Hours	kWh	kWh/m²/year	kWh/m²/hr
Office (All)	4,570	3,457,000	242	0.060
Public sector	2,420	1,380,000	109	0.048
Private sector	5,350	4,202,000	290	0.064
One shift	2,120	2,389,000	158	0.075
Three shift	8,120	6,929,000	348	0.044
Conditioned >=50%	4,820	3,615,000	269	0.065
Conditioned <50%	3,420	2,727,000	83	0.037
Hospitals	**# Beds**	**kWh**	**kWh/m²/year**	**kWh/bed/year**
Multi specialty hospitals	170	2,398,000	362	13,998
Hotels	**# Rooms**	**kWh**	**kWh/m²/year**	**kWh/room/year**
1-3 star Hotels	100	2,347,000	271	19,396
4-5 star Hotels	150	3,513,000	274	20,381
Shopping Malls		**kWh**	**kWh/m²/year**	**kWh/m²/hr**
Shopping Malls		2,370,000	252	0.056

Source: Building Energy Benchmarking study undertaken by the USAID ECO-III Project

Benchmarking or Star Labeling Challenge

- Simplicity Vs. Technical Accuracy
- Goal is to develop MPG for the building?
  - Schneider Electric is fully committed to support this GOI initiative
- What is the Total Floor Area for commercial building sector
- Make building performance Comprehensible, Measureable, and Visible
- Induce a change in the O&M culture
  - Strongly discourage “Jugaad” and “problem fixing” and encourage/ reward “problem solving”

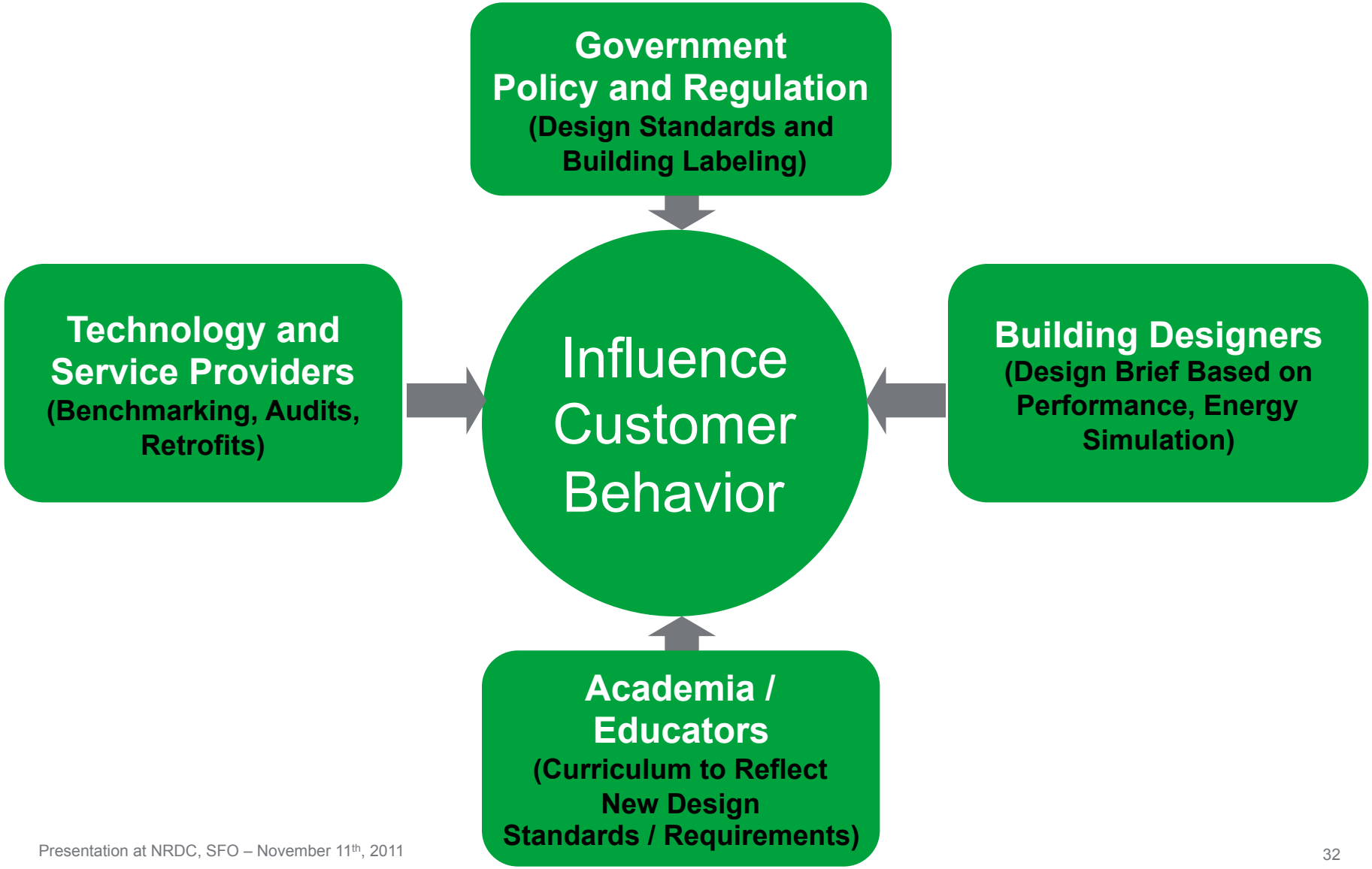
Key Attributes of a Performance Indicator



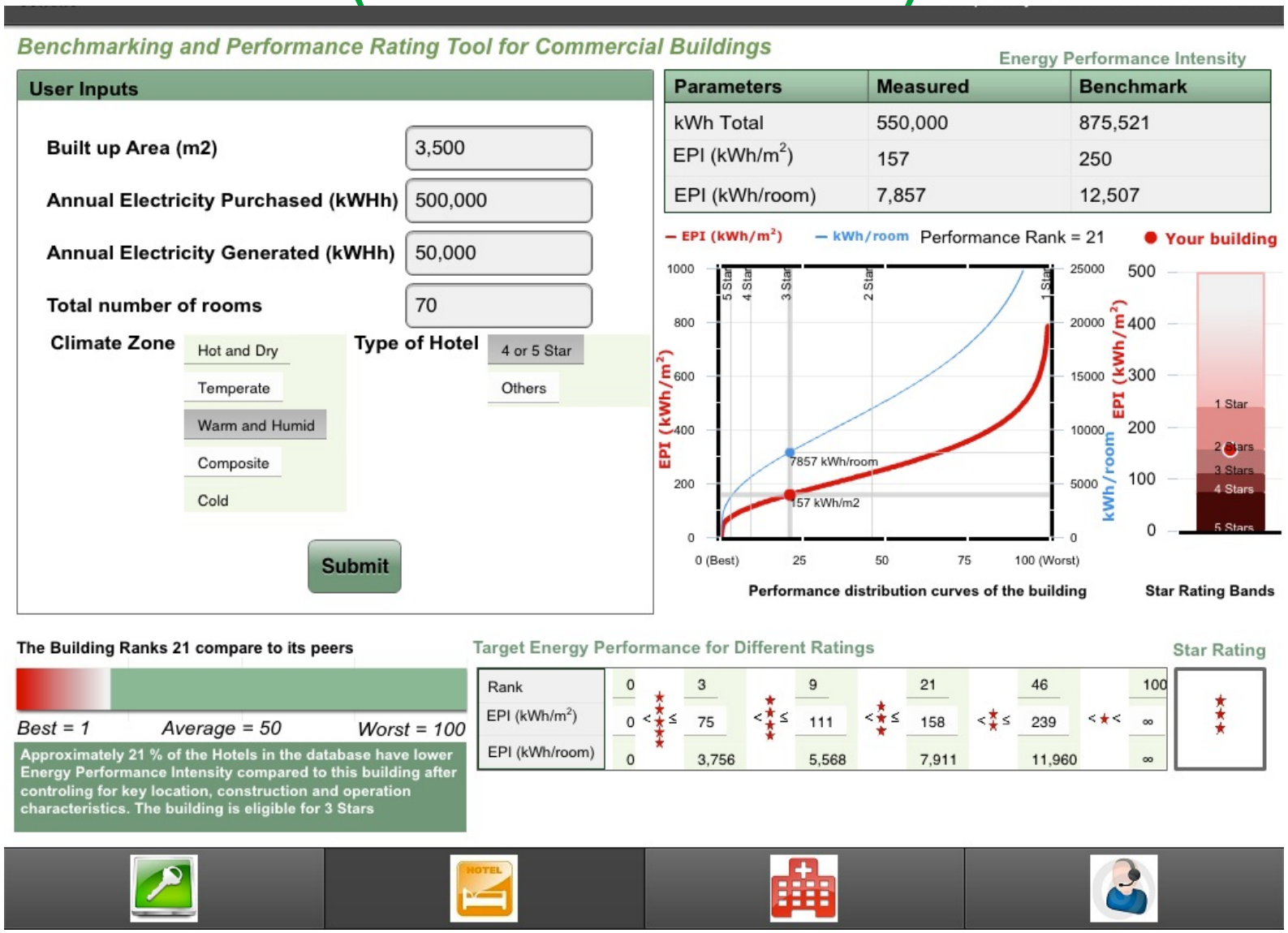
> KWh/m2/yr

is what we need to look at

Key Stakeholders and Impact of Performance Indicator



Web-based Benchmarking Tool (www.eetools.in)



Top 10 Reasons Why ESCO Market Continues to be a Mirage in India?

1. O&M and R&R are known concepts but very few organizations dedicate resources (reasonable budget and manpower)
2. Clients want EE projects with a payback of no more than three years: an ROI of 33%
3. Only Option C is an acceptable M&V approach for most clients; By comparison Option A is used in 90% of performance contracts around the world by ESCOs
4. India has more than 80 ESCOs but very few successful performance contracts
5. Financing is the panacea for all the ills that plague the Energy Services sector
6. Performance Contracting is a partnership: All powers for decision making rest with the client and all responsibilities and risks will rest with the ESCOs
7. Endless cycle of meetings but no action/decision; ESCOs should plan for a 2-3 year project development cycle with no guarantee
8. Small government buildings go for performance contracts when AMCs are most likely will provide solutions
9. Project is considered successful if EOI and RFP stage is reached
10. “IGAs” and DPRs have become the end rather than a means to an end

NZEB at CEPT University: A Pilot Project

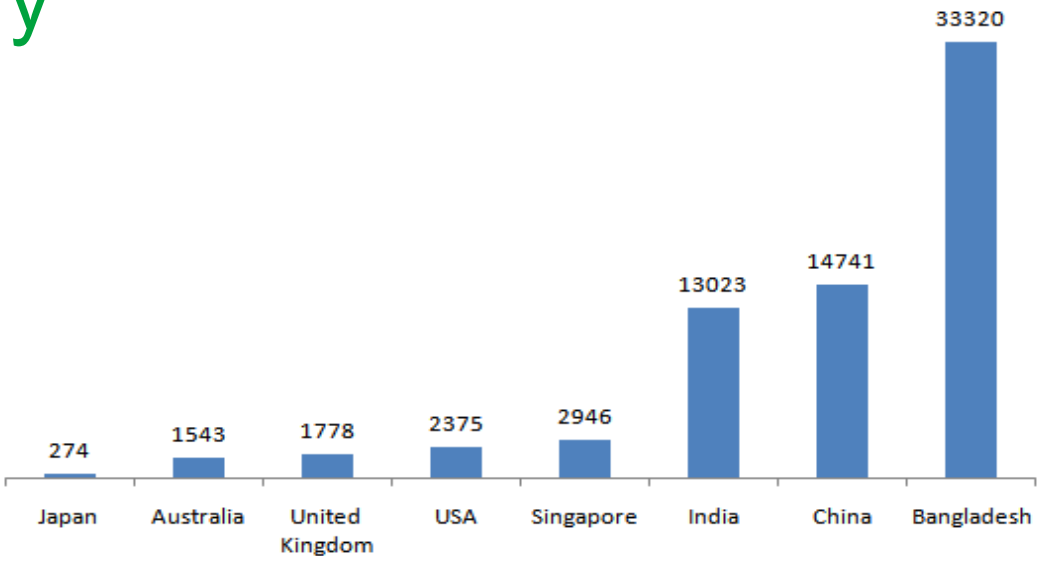
- **Objective**: Design a “very low energy” building and generate enough power on site to be self-sufficient
- **Process**: Put together a team of top notch Indian and International consultants with clear design brief and milestones
- **Performance Brief**:
  - Reduce energy use by 75%
  - Reduce or eliminate air-conditioning completely
    - Use innovative HVAC technology
  - Use adaptive thermal comfort to make it happen
  - Use as much daylight as possible (LPD < 0.25 W/ft^2)
- **Lessons Learned**
  - Bridging the cultural mindset and expectations gap
  - High cost of international consultants Vs. Perceived value addition
  - Lack of coordination between consultants and equipment/control vendors

Tragedy of a Pilot Project

- Top management will pay the same attention to all projects
- Integrated Building Design is a wonderful concept that will work swimmingly well in all projects
- Companies will invest (in terms of people and time) the same level of effort in all projects
- The A-team of designers, consultants, engineers, and site people will also work on typical projects
- Lessons learned are portable and replicable
- No extra cost is incurred in ensuring the success of the pilot project
- Pilot projects set the benchmark for performance which can easily be matched by typical projects

Addressing the Skills Gap

The Skills Gap in the Indian Construction Industry



Urban population per Registered Architect in Different Countries of the World

Background of Labor Force	Numbers (in 000s) in 2005	Percentage
Engineers & Architects	822	2.65
Technicians & Foreman etc.	573	1.85
Clerical	738	2.38
Skilled workers	3267	10.57
Unskilled workers	25600	82.45
Total	31000	100.00

Source: Planning Commission, Government of India *Source: Survey on Architectural Profession around the world, UIA, 2005*

Employment Challenges

- Employability challenge complicated by
  - Geographic, Sector, and Skills mismatch
    - people have skill sets different from what employers are looking for - Economist
- One million young people who will join the labor force every month for the next 20 years
- 93% employment in the unorganized sector sabotages sustainable and scalable skills development
  - 300 million people are stuck in low-productive jobs
  - Vocational training is a dead end 5,500 ITIs and 1,745 polytechnics have massively under-performed
  - China, by comparison, has 500,000 similar institutes
- Demographic Dividend or a Disaster in the Making: Only 13% of potential talent fit for recruitment by MNCs (McKinsey 2005)
- Building sector consumes 35% of India's energy production and is projected to grow @ 6.6% until 2030 (McKinsey 2009)
- Track the 3Es: Education, Employability, Employment

Source: Business Today (April 4th, 2011) and India Today (August 8th, 2010)

Motivation

- By 2030, India will have a GDP of $4 trillion and a population of 1.5 billion
- Govt. of India Goal: Making 500 million people employable by 2022
- National Knowledge Commission (2009) aims to set up 30 new universities, 373 new degree colleges, 100 new polytechnics, 7 IIMs, 3 new IITs, 5 IIScs, 10 NITs, 20 IIITs, 2 SPAs
  - Many will help develop skills to be employed in infrastructure sector

Source: Business Today (April 4th, 2011) and India Today (August 8th, 2010)

Importance of Plumbing and Philosophy

The society which scorns excellence in plumbing as a humble activity and tolerates shoddiness in philosophy because it is an exalted activity will have neither good plumbing nor good philosophy: neither its pipes nor its theories will hold water

- John W. Gardner

Bottom Up Approach

- Capacity Building
  - Organization Train the Trainer Workshops
  - Organization of Regional Workshops (simulating classroom teaching)
- Development/Refinement of Curriculum
  - Building Physics
  - Energy Simulation
- Helping Establish Energy Simulation Computer Labs
  - Help students in “modeling” complex modern buildings
  - Familiarity with state of the art energy simulation tools
    - DesignBuilder, EnergyPlus, etc.
- Guidance on Establishing Building Diagnostics Labs
- Magic of Great Books
  - Teaching and Research Aid for Faculty Members
  - Reference Materials for Students
  - Building Physics, Lighting Design, Heat Transfer, HVAC Design, Building Simulation, Acoustics, Research/Scientific Methods, Statistics, Sustainable Design, E-Source Technology Atlas

Schneider Electric

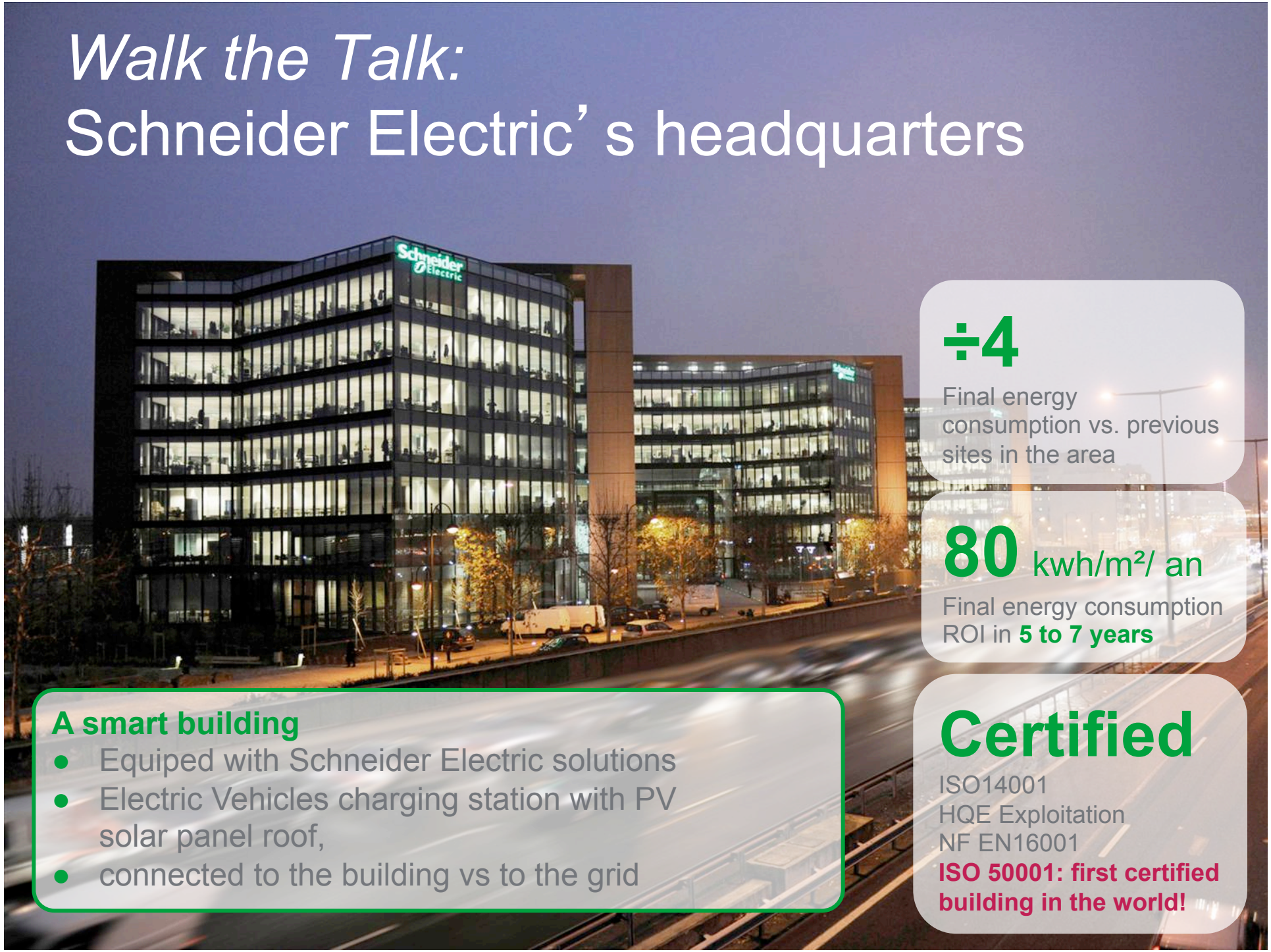
What is Schneider Electric Doing to Support Energy Efficiency in Buildings

- Benchmarking Building Performance
- Provide Industry Support to Collect, Analyze, and Display Results through Web-based Tool
- Help create energy consumption and building performance data in the public domain
- Identify specialized electrical management solutions to make energy safe, reliable, green, and productive
  - Make Residual Current Circuit Breaks Mandatory
  - Advocate the use Fixed Ground Electrical Power (FGEP) at airports and Shore Connections at the Ports.

ISO 50001: Global Energy Management Standard

- ISO 50001 is an international energy management standard that
  - governments are promoting
  - companies are adopting
- ISO 50001 brings benefits to organizations:
  - A way to save energy and cost and to reduce CO2 emissions
  - A way to improve compliance and image standing
  - An additional brick in the global management system
  - All within a recognized, official, international framework
  - Based on **Quantifiable Performance Targets**
- Offers a platform for public private partnership
  - Schneider Electric and BIS are jointly developing capacity building programs
  - ISO 50001 well suited to support PAT and Star Labeling (bldgs) program

Walk the Talk:
Schneider Electric's headquarters



÷4

Final energy consumption vs. previous sites in the area

80 kwh/m²/ an

Final energy consumption
ROI in **5 to 7 years**

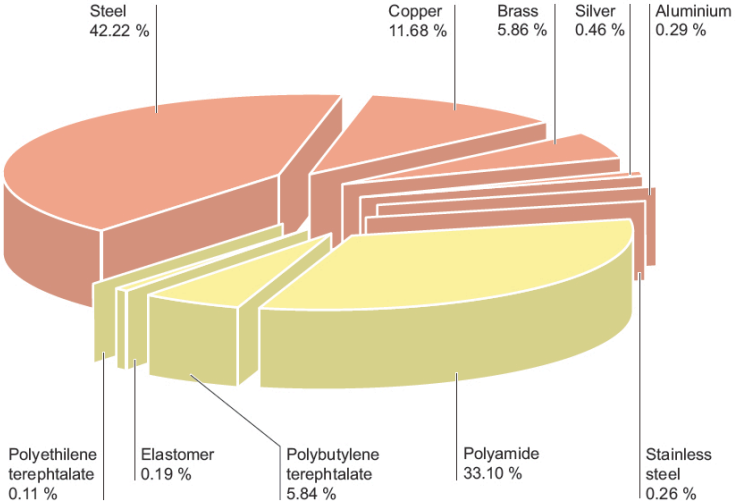
Certified

ISO14001
HQE Exploitation
NF EN16001
ISO 50001: first certified building in the world!

A smart building

- Equiped with Schneider Electric solutions
- Electric Vehicles charging station with PV solar panel roof,
- connected to the building vs to the grid

Product Environmental Profile of TeSys



PEP ecoPASSPORT®

Environmental indicators	Unit	For a TeSys LC1K0910M7			
		S = M + D + U	M	D	U
Raw material depletion	Y-1	$6.86\ 10^{-14}$	$6.78\ 10^{-14}$	$1.00\ 10^{-18}$	$7.66\ 10^{-16}$
Energy depletion	MJ	$8.77\ 10^{+02}$	17.1	$7.22\ 10^{-01}$	$8.59\ 10^{+02}$
Water depletion	dm^3	$1.23\ 10^{+02}$	11.1	$6.98\ 10^{-02}$	$1.12\ 10^{+02}$
Global warming potential	g≈CO_2	$5.49\ 10^{+04}$	$9.36\ 10^{+02}$	62.8	$5.39\ 10^{+04}$
Ozone depletion potential	g≈CFC-11	$6.84\ 10^{-03}$	$1.35\ 10^{-04}$	$4.13\ 10^{-05}$	$6.67\ 10^{-03}$
Photochemical ozone creatione	g≈C_2H_4	19.8	$7.38\ 10^{-01}$	$7.79\ 10^{-02}$	19
Air acidification	g≈H^+	9.38	$2.24\ 10^{-01}$	$1.65\ 10^{-02}$	9.14
Hazardous waste production	kg	$7.77\ 10^{-01}$	$4.78\ 10^{-03}$	$2.24\ 10^{-05}$	$7.72\ 10^{-01}$

Schneider's RoHS Compliance

- RoHS (Restriction of Hazardous Substances) is a European directive primarily for products used in household application
  - Required to eliminate following substances in certain Electrical and Electronic Equipment put on sale in Europe
    - Mercury (Hg)
    - Lead (Pb)
    - Cadmium (Cd)
    - Hexavalent Chromium (Cr6+)
    - Polybrominated Biphenyls (PBB)
    - Polybrominated Diphenyl Ethers (PBDE)
- Schneider Electric is committed to fully complying with the RoHS directive and going beyond it in many cases

Electrician Training Program

- Goal:
  - Train electricians for promoting safe and reliable electric installation
  - Train 4000 electricians by 2012.
- Selection of candidates for the training:
  - Technicians: ITI qualified, 10+2 passed
  - Entrepreneurs: Graduates, ITI, 10 +2 passed
  - Electricians: 8th to 10 +2 passed or drop outs
- Duration of the training
  - 4 months (3 months theory and practical training + 1 month on job training at the site)
- Sample Course content
  - Basics of house wiring, building wiring , electrical safety
  - Introduction to Electrical Products
  - Trouble shooting of electrical installation in residential and commercial building.
  - Training on Solar energy solution
  - Spoken English , Written English, Computer
  - Soft Skill – Customer Interaction, Communication

Conclusion

Recommendations

- ECBC should be the highest priority for the Govt.
  - Develop capacity building roadmap for the next 10 years, involve top professionals, dedicate resources,
  - Invest in the development and maintenance of high quality web-based compliance tools
    - Realize that it is a very expensive, skillful, difficult and challenging task
- Energy Efficiency Guidelines for Residential Sector should be developed immediately
  - Who'll drive the program?
  - Use the donor programs effectively and strategically
- Emphasize Building Performance
  - Captialize on BEE's Star Labeling branding
  - Introduce integrity in green building labeling program
- Learn from others and own mistakes
  - Set up Collaborative R&D Centers

Things to Avoid

- Avoid the Urge to Work with Successful and "Well-known" Players/ Organizations Only
  - Yes, it may be difficult in the beginning
  - But it can give better bang for the buck in the end and you'll be doing India a huge favor
- Don't Ignore Unglamorous Activities
  - Address the skills gap at all levels
    - Even though it is not sexy, it is the fundamental building block
    - Building trade professionals, Architects, Engineers, Researchers, and Consultants
    - Develop Joint Centers of Excellence
- Transplanting International Success Stories and Thinking
  - For Political Reasons
  - Success will not be guranteed for other reasons
- Jumping into Tools Development Without Sufficient Resources
  - Buy-in from key stakeholders will be crucial
  - Understand and appreciate that it will be an expensive process
  - Put the right team together (subject matter and IT experts)

Lessons Learned From ECO-III Project

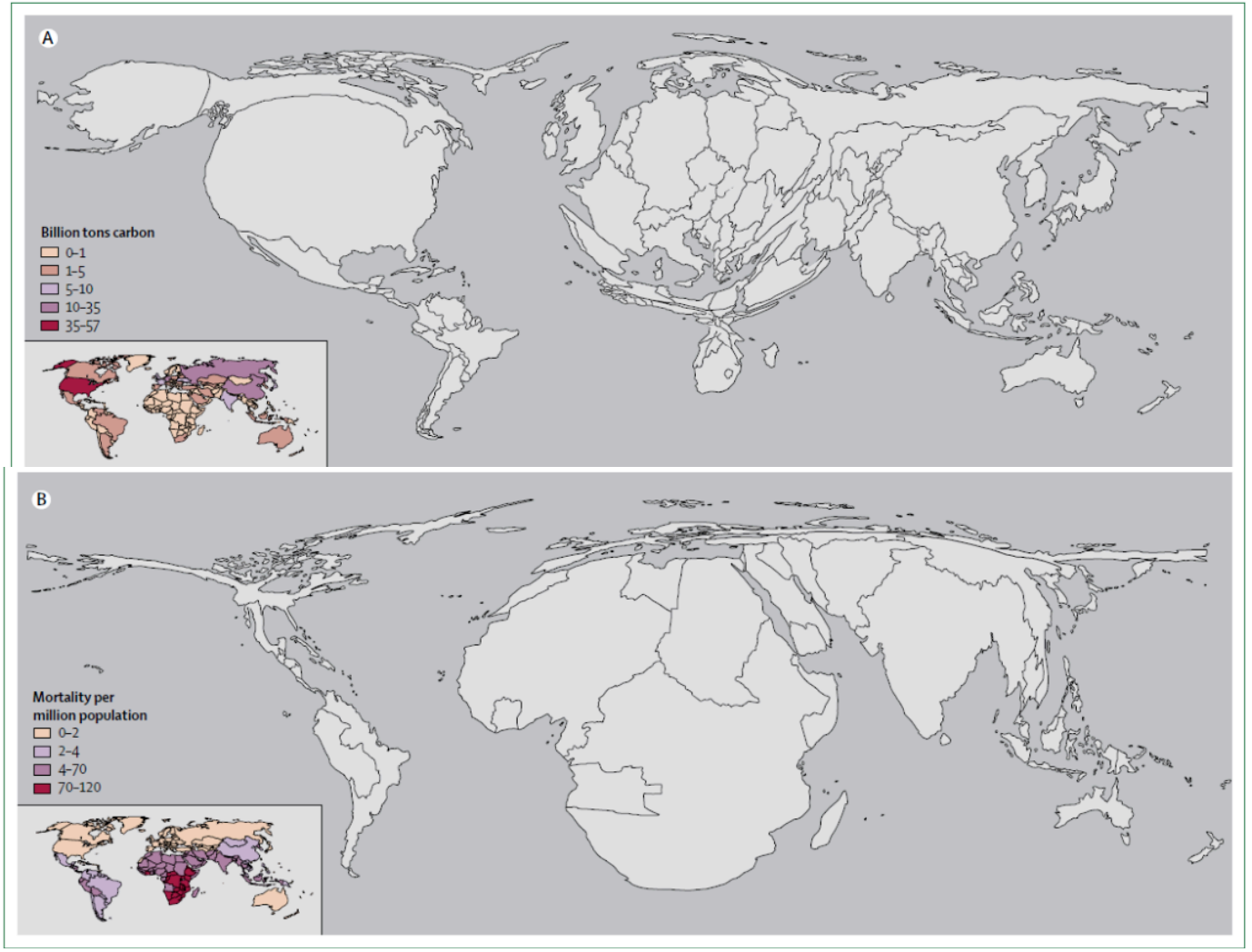
- Identify the sector and prioritize activities
- Key players (BEE, USAID, and IRG) must show flexibility
  - Very difficult to do in practice and deemed to be too risky by both parties
  - Identified by BEE as the most important parameter contributing to the success of ECO-III project
- Use local consultants and experts to the extent possible
- Working at the central govt. level is easier than at the state govt. level
  - Transfer of govt. officials remain one of the biggest stumbling blocks
- A highly motivated, driven team willing to push boundaries and to go the extra mile
- Building Sector attracting multiple donors, consultants, and NGOs
  - Harnessing the resources, interest and expertise
    - UNDP-GEF, PACE-R and PACE-D, SDC, ClimateWorks/Shakti
  - Avoid re-invention and duplication – Big challenge
- **PRAY THAT LUCK WILL be on YOUR SIDE**

Acknowledgements

- **USAID India Mission:** for designing and funding the ECO program that allowed the entire team to work on such an exciting project;
- **Ministry of Power and Bureau of Energy Efficiency:** for providing a national platform under the bilateral agreement, offering valuable advice and guidance, keeping the project team honest and focused and for giving the team an opportunity to provide technical assistance to BEE and to state government organizations;
- **International Resources Group:** for putting together the winning proposal, assembling and supporting the team, providing the management, administrative, and contractual support, which was vital throughout the project;
- **All Project Partners:** for their tremendous contributions and support throughout the five years of the project;
- **ECO-III Project Team** consisting of Anurag Bajpai, Bibhash Das, Dhruv Jain, Madhav Kamath, Ravi Kapoor, Vidhi Kapoor, Swati Lal, Kailash Mahajan, Sanyogita Manu, Meetu Sharma, Nims Sharma, Sumit Kumar Sharma, Manoj Srivastava, Ankur Tulsyan, Neerav Verma, Chander, Mukesh, and Surender as well as Vikas Arora, Shruti Narayan, and Saket Sarraf for their tireless work and the pride that they showed while working on the project - they are the ones who made ECO-III project what it was.

ECO-III on the web: www.eco3.org, www.eetools.in

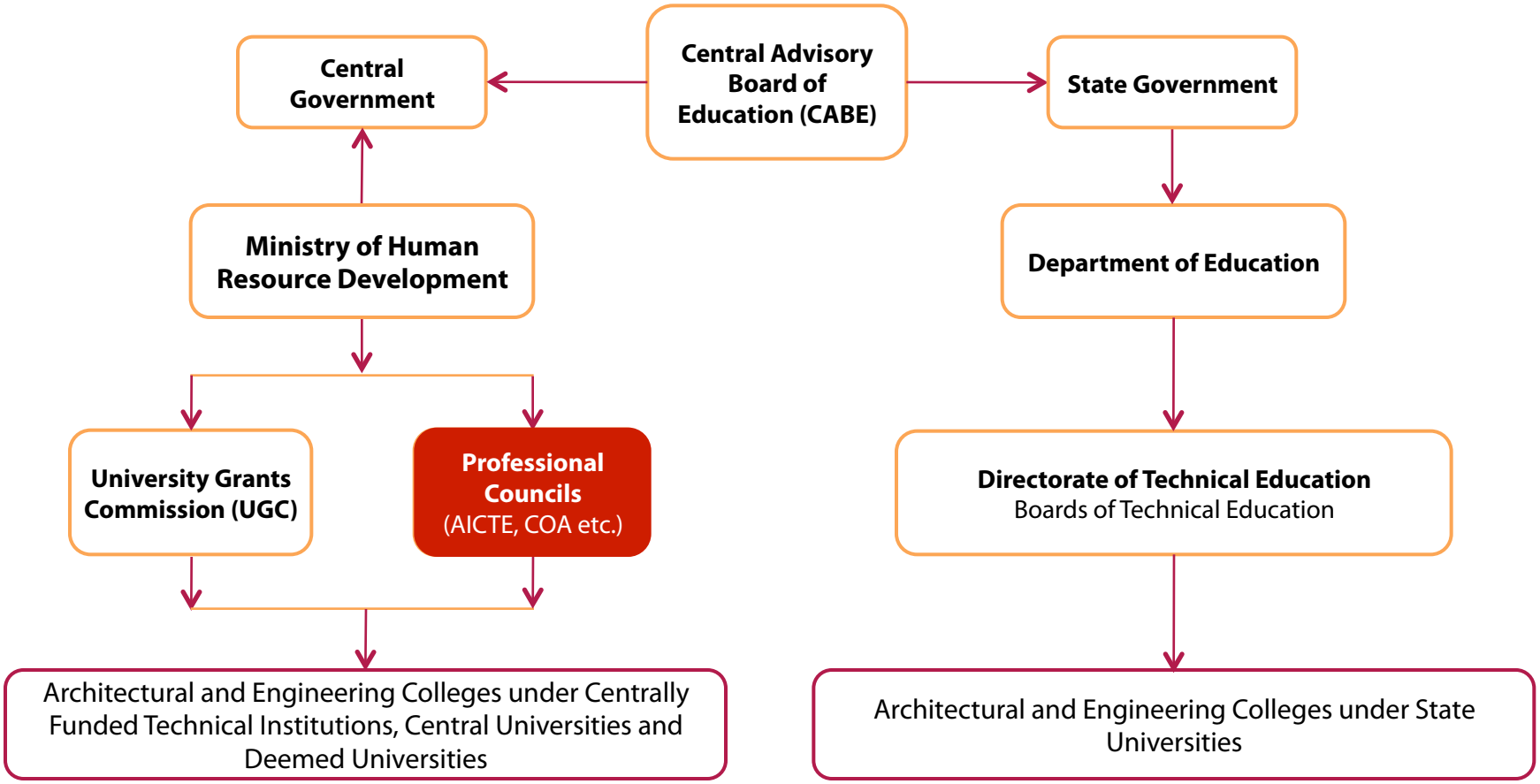
Impact on India From Climate Change



Source: Managing the Health Effects of Climate Change, The Lancet Commissions, 2009

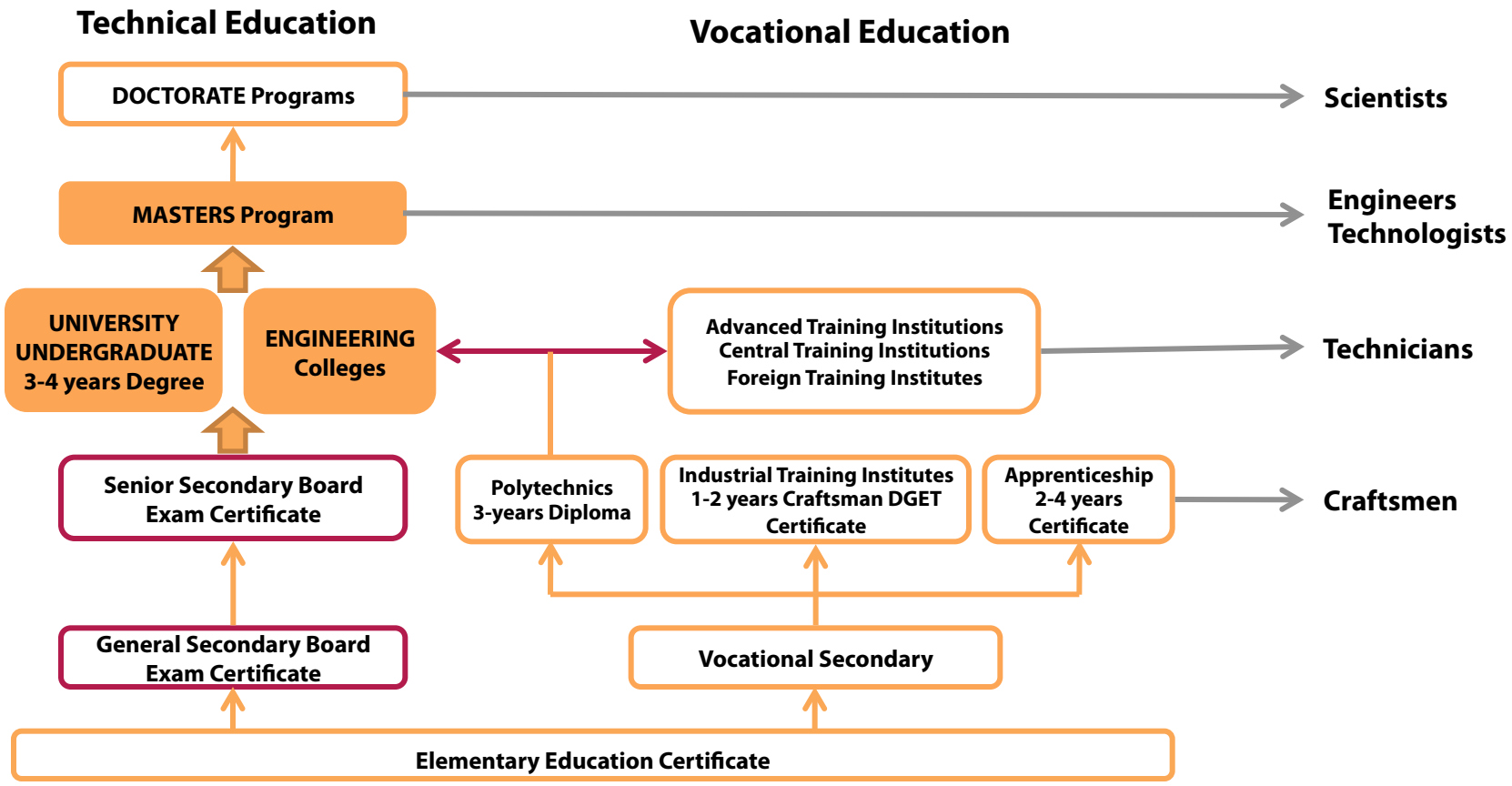
Make the most of your energy™

Architectural Education in India - 1



Source: Planning Commission, Government of India

Architectural Education in India - 2



Source: World Bank, 2008

The metric can drive the outcome

Indicator = measure of use/measure of extent

THE NUMERATOR

- **Site** energy: creates a bias to electricity, discourages cogeneration.
- **CO_2:** unstable. Creates a bias to fuels with low carbon factors *(and not always low-C in practice)* at the expense of energy efficiency.
- **Source** energy: outcome varies with source factors (particularly for electricity), which may bear no relation to building energy efficiency.
- Energy **cost**: too influenced by contract and market conditions, often confidential, and in the past has been distracting. *Internal use only.*
- **Renewable** energy: may reward production over demand reduction.

THE DENOMINATOR

- **Per unit floor area**: ***Do we know the definitions?*** Tends to reward spatially inefficient and under-used buildings. *But relatively robust.*
- Per person, per unit of production, per unit of profit, per occupied hour … *Useful secondary indicators, but can be unreliable/unstable.*

To avoid massive unintended consequences, we need

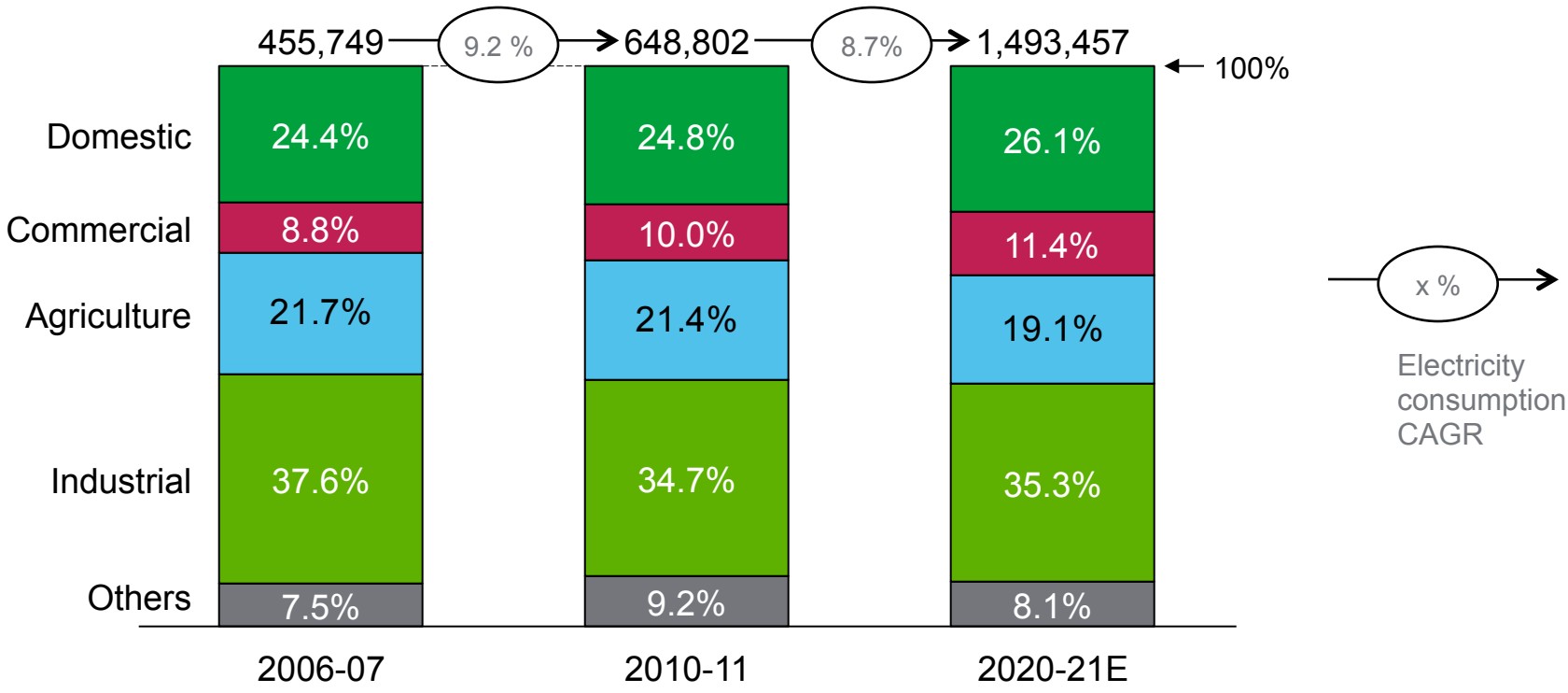
a set of performance indicators, and opportunities to review weights.

SOURCE: Usable Building Trust

Infosys Hyderabad Campus: Innovation Through Experiment

- **Objective**: Address the "burgeoning cooling demand" and quantify the solution
- **Technologies:** Chilled Beam and Conventional Chiller
- **Implications**:
  - Identify ways to substantially reduce the ~ 100 GW of electrical demand to satisfy cooling demand in 2030
  - Learn by experimenting with non vapor compression air-conditioning technologies that have huge potential but are not mainstream
  - Apply the concept of adaptive thermal comfort to enhance the impact
- **Lessons Learned**
  - 30-40% of energy savings being achieved over conventional chiller system
  - Better thermal comfort achieved per field experiment performed by a German university team
  - Avoiding condensation and assuring minimum amount of fresh air are challenges that need to be tackled

Electricity Consumption (in Million kWh)



Source: Central Statistics Organization (for 2007 fig)

18th Electric Power Survey draft report, CEA, July 2011

1. Others include Railways, Public water pumping & lighting and bulk supply

ECO-III Project Partners – Key to Success

- **Public Sector Partners**
  - Bureau of Energy Efficiency
  - CPWD, Reserve Bank of India
  - GEDA, PEDA , WBREDA, RRECL
  - Gujarat Urban Development Company (GUDC)
  - US DOE, LBNL, PNNL
  - World Bank
- **Industry Associations**
  - CII Green Business Center
  - ISHRAE
  - NASSCOM
  - GESCSL, Vatva Industrial Estate
  - Glazing Society of India
- **Private Sector Partners**
  - Alliance to Save Energy, Dalkia Energy Services Ltd. (formerly DSCL), The Weidt Group, NPC, Conzerv, NISST, See-Tech, AEEE, EVO
  - Infosys
  - DLF
  - E-Source, Colorado, USA
  - DesignBuilder, UK
- **Academic Institutions**
  - 29 Architecture/Engineering Colleges
    - CEPT, IIT-KGP, IIT-R, IIIT, MNIT
  - IIM Ahmedabad
  - Technical University of Vienna
  - Jadavpur University